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(54) **ELECTRIC AND BALLISTIC CONNECTION THROUGH A FIELD JOINT**

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H01R 24/38	(2011.01)
H01R 103/00	(2006.01)

(52) **U.S. Cl.**

CPC ***E21B 43/1185*** (2013.01); *H01R 24/38* (2013.01); *H01R 2103/00* (2013.01)

(58) **Field of Classification Search**

CPC E21B 17/00; E21B 17/028; E21B 17/023; E21B 43/11; E21B 43/1185; H01R 24/38
USPC 166/297, 376, 65.1, 55, 55.2
See application file for complete search history.

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(57) **ABSTRACT**

A perforating system having annular connectors for attachment between adjacent perforating guns and connectors. The connectors include male and female connectors with respective outer and inner contact surfaces. The connectors also include attachment for electrical detonators and/or booster charges for transferring ballistic detonations between the perforating gun and connector sub.

24 Claims, 5 Drawing Sheets

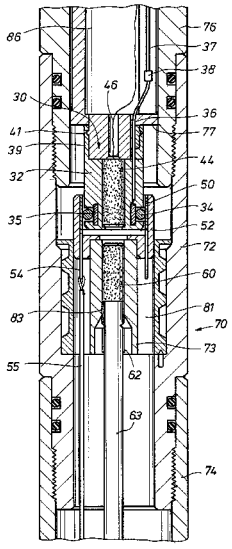


FIG.1
(PRIOR ART)

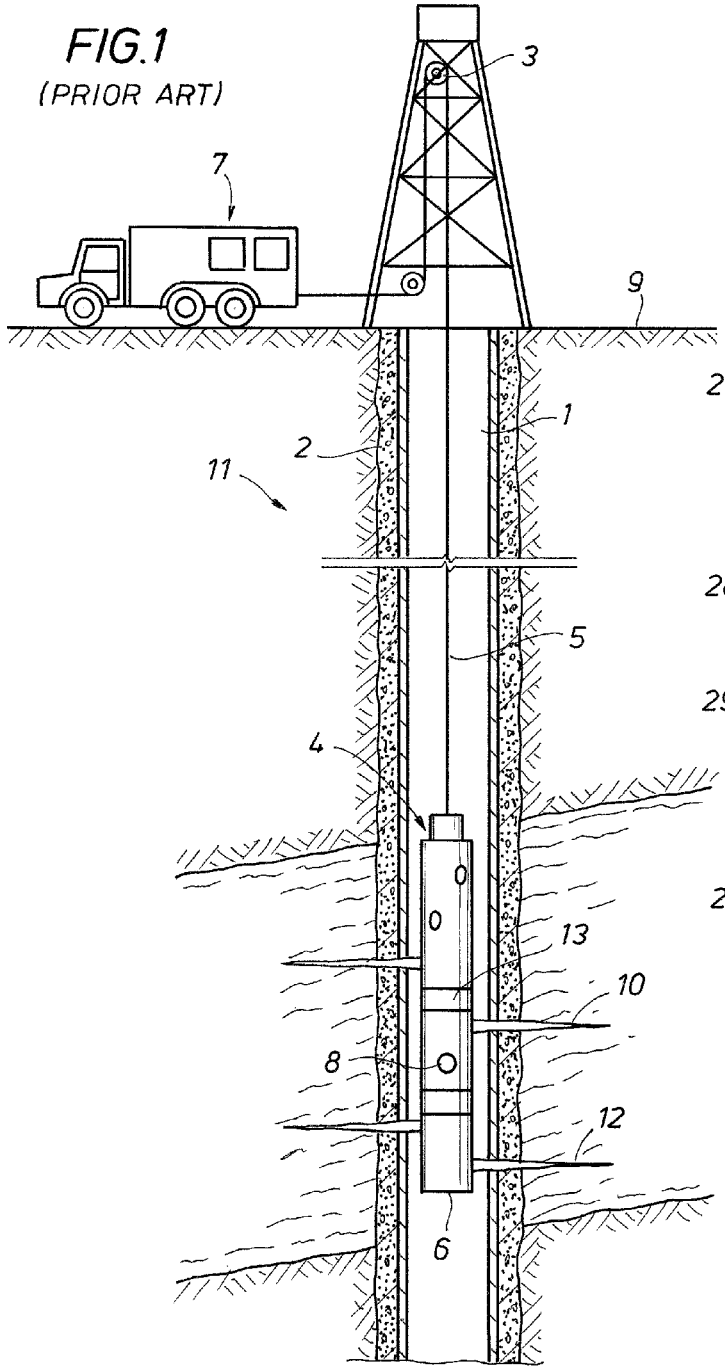
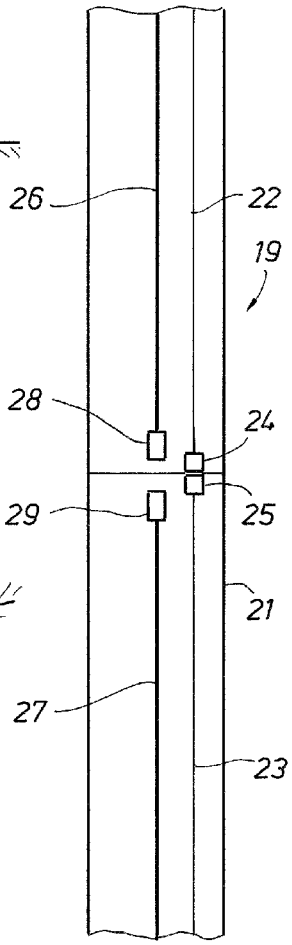


FIG. 3



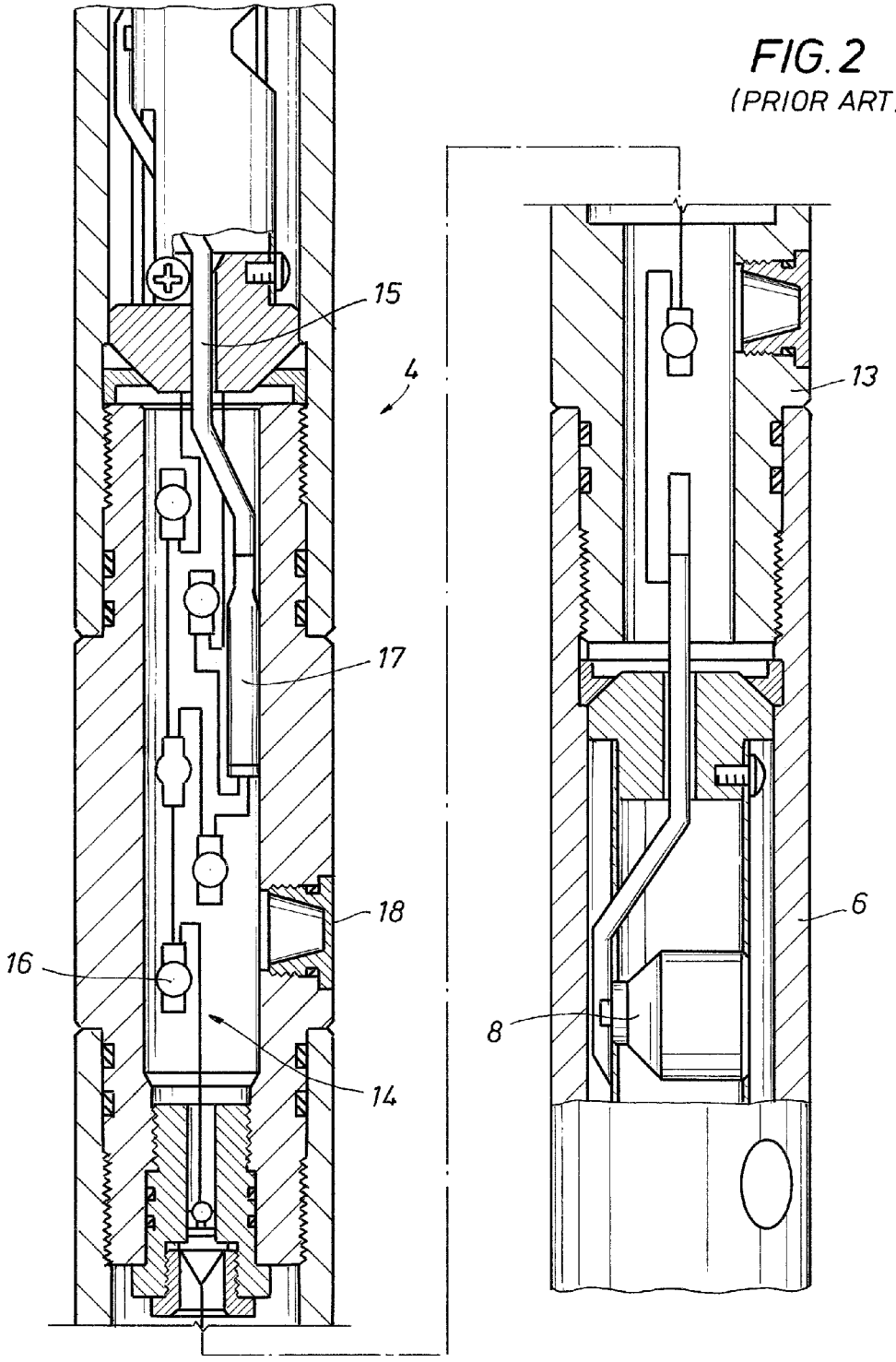
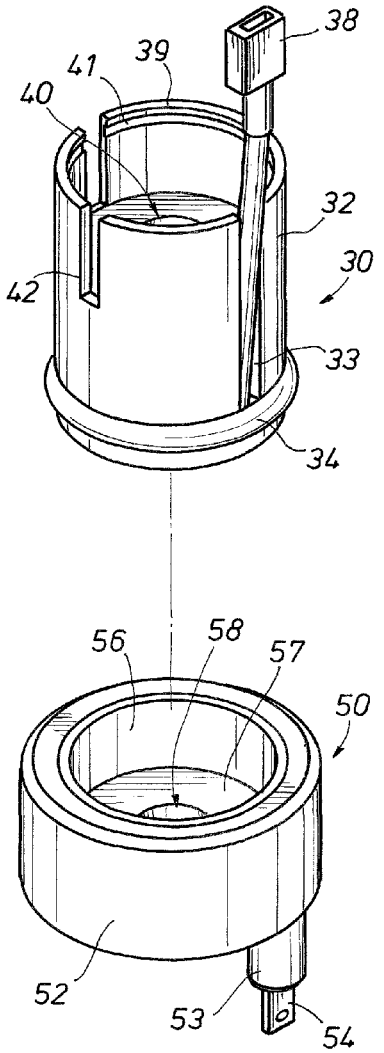


FIG. 2
(PRIOR ART)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52
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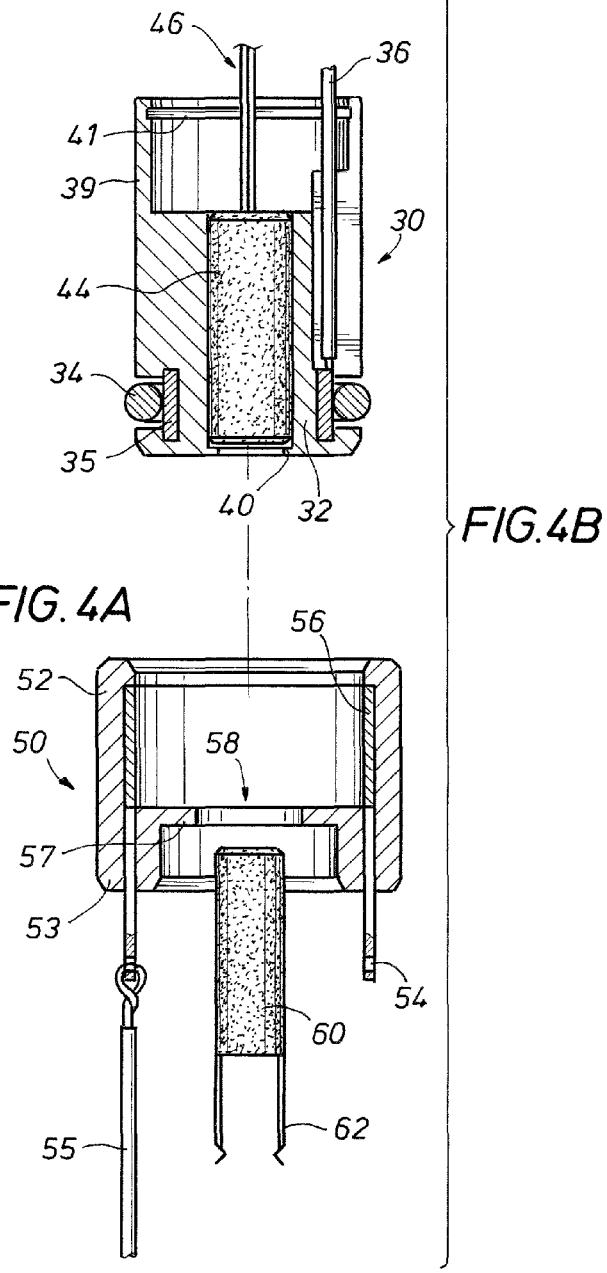
54

FIG. 4A


46
36
41
39
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44
34
35
40
32
56
52
50
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57
53
54
60
62
55

FIG. 4B

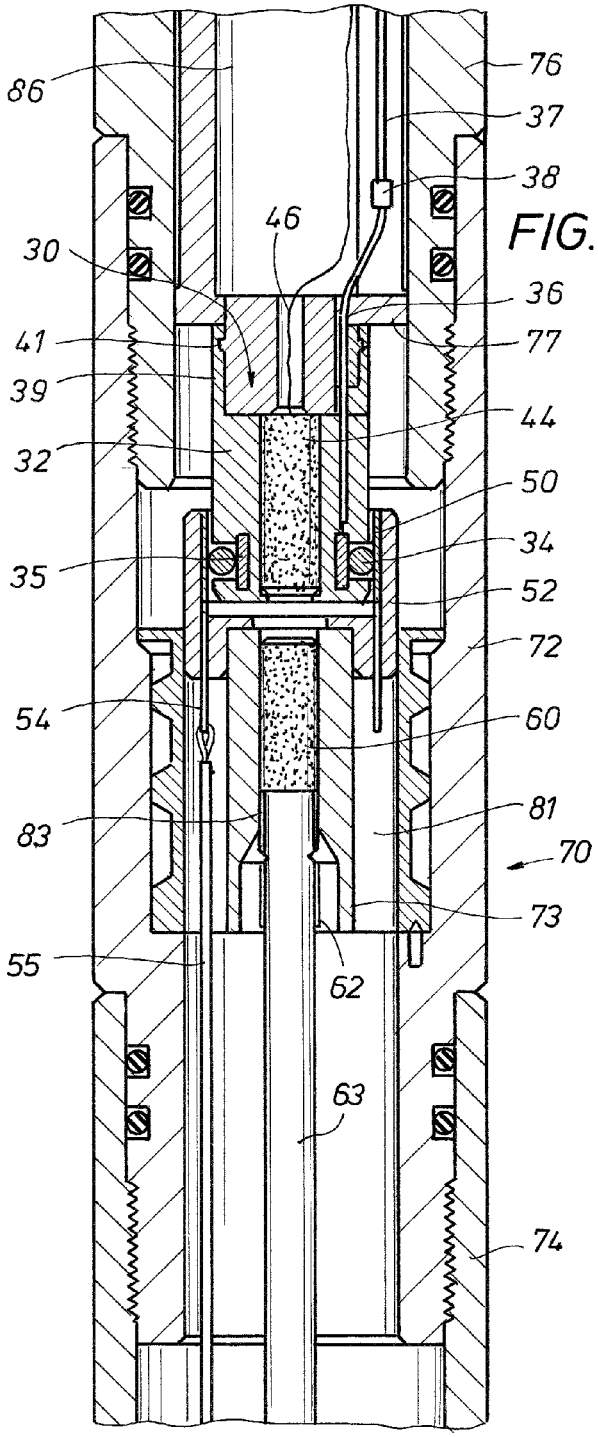
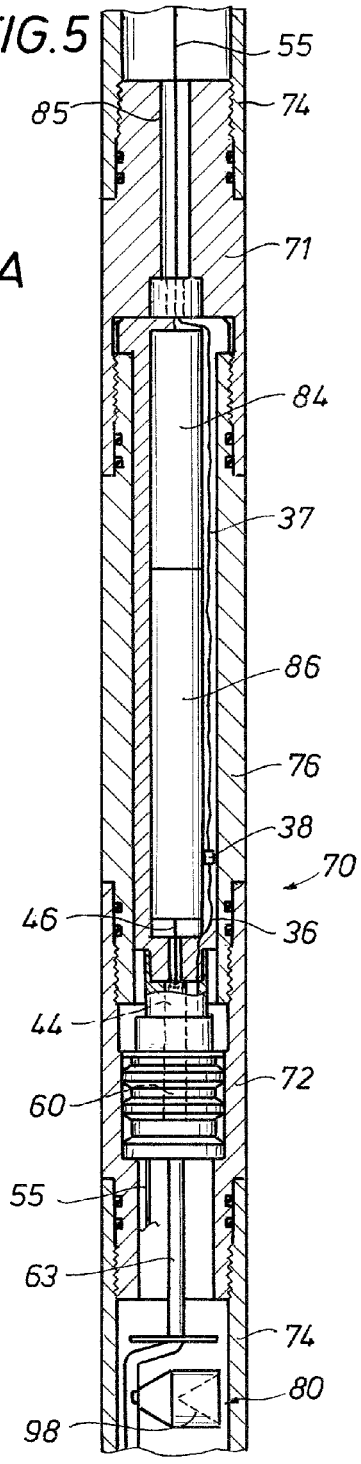

86
76
37
38
46
30
36
41
77
39
44
32
50
34
35
52
72
54
60
81
83
70
73
55
62
63
74

FIG. 5A

FIG. 5


55
85
74
71
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37
86
76
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70
46
36
44
72
60
55
63
74
80
98

FIG.7

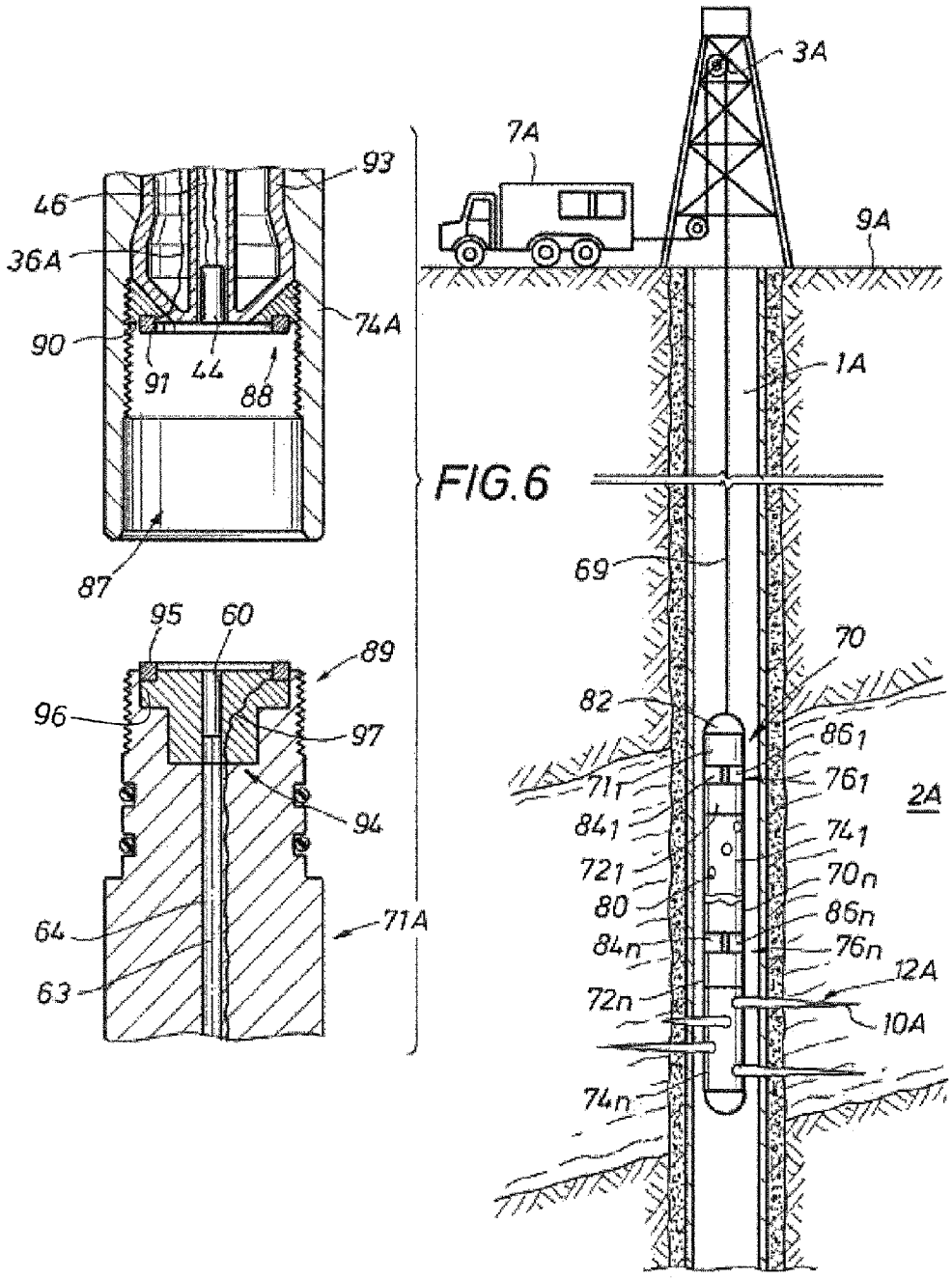
3A
7A
9A
1A
69
70
82
86₁
76₁
71₁
2A
84₁
74₁
72₁
70n
80
86n
84n
76n
12A
72n
10A
74n

FIG.6

93
46
36A
74A
90
91
44
88
87
95
60
89
96
97
94
64
71A
63

ELECTRIC AND BALLISTIC CONNECTION THROUGH A FIELD JOINT

BACKGROUND

1. Field of Invention

The invention relates generally to the field of oil and gas production. More specifically, the present invention relates to a perforating system having signal circuit connectors on adjacent members of a perforating string that can be put into direct contact.

2. Description of Prior Art

Perforating systems are used for the purpose, among others, of making hydraulic communication passages, called perforations, in wellbores drilled through earth formations so that predetermined zones of the earth formations can be hydraulically connected to the wellbore. Perforations are needed because wellbores are typically completed by coaxially inserting a pipe or casing into the wellbore. The casing is retained in the wellbore by pumping cement into the annular space between the wellbore and the casing. The cemented casing is provided in the wellbore for the specific purpose of hydraulically isolating from each other the various earth formations penetrated by the wellbore.

Perforating systems typically comprise one or more perforating guns strung together, these strings of guns can sometimes surpass a thousand feet of perforating length. In FIG. **1** an example of a perforating system **11** is shown having a perforating gun string **4** with perforating guns **6** coupled together by connector subs **13**. The gun string **4** is shown disposed within a wellbore **1** on a wireline **5**. The perforating system **11** as shown also includes a service truck **7** on the surface **9**, where in addition to providing a raising and lowering means, the wireline **5** also provides communication and control connectivity between the truck **7** and the perforating gun **6**. The wireline **5** is threaded through pulleys **3** supported above the wellbore **1**. As is known, derricks, slips and other similar systems may be used in lieu of a surface truck for inserting and retrieving the perforating system into and from a wellbore. Moreover, perforating systems may also be disposed into a wellbore via tubing, drill pipe, slick line, coiled tubing, to mention a few.

Included with the perforating gun **6** are shaped charges **8** that typically include a housing, a liner, and a quantity of high explosive inserted between the liner and the housing. When the high explosive is detonated, the force of the detonation collapses the liner and ejects it from one end of the charge **8** at very high velocity in a pattern called a "jet" **12**. The jet **12** perforates the casing and the cement and creates a perforation **10** that extends into the surrounding formation **2**.

FIG. **2** is a side partial sectional view of a portion of a known perforating gun string **4** depicting an example connection between a perforating gun **6** and a connector sub **13**. Also shown in FIG. **2** is an example detonation system for the shaped charges **8**. The detonation system illustrated includes a detonation cord **15**, that when ignited imparts a shock wave to initiate shaped charge **8** detonation. The system further includes an electrical circuit **14** that delivers electrical signals from the surface to initiators **17** for selectively igniting a specific detonation cord **15**. Wire connectors **16** are shown within the circuit **14** for providing electrical communication between components within the circuit **14** and external to the circuit **14**.

The circuits **14** therefore can be implemented for selective detonation of shaped charges **8** in specific perforating guns. Final assembly of the circuits **14**, such as making up the wire connectors **16**, is performed within the body of the guns **6**.

Ports **18** with removable covers are shown for accessing the circuits **14** and connectors **16**. The ports **18** however may leak when exposed to high pressures downhole. Moreover, wires of the circuit **14** that pass between adjacent connector subs **13** and guns **6** can become twisted or otherwise damaged during assembly.

SUMMARY OF INVENTION

Disclosed herein is a tool string of connected bodies with connections that can transmit signals and also transfer ballistic charges between the bodies. The signals can be electrical, electromagnetic, full spectrum light waves, radio waves, or combinations thereof. Also disclosed herein is a perforating system having annular connectors for attachment between adjacent perforating guns and connectors. The connectors include male and female connectors with respective outer and inner contact surfaces. In an embodiment, the connectors include attachment for detonator and/or booster charges for transferring ballistic detonations between the perforating gun and connector sub. In an example, disclosed is a perforating system that includes a first perforating string member having a first annular electrical contact, a first signal member in communication with the first annular electrical contact, and an end having a first connection fitting, a second perforating string member having a second annular element contact, a second signal member in communication with the second annular electrical contact, and an end having a second connection fitting selectively in a configuration attached with the end having a first connection fitting, so that when the end having a second connection fitting is attached to the end having the first connection fitting, the first and second annular electrical contacts are, in an embodiment, coaxially contacting, and the first and second signal members are in electrical communication. The perforating string members can be a perforating gun, a connecting sub, a booster sub, or a control sub. The first annular electrical contact may be a sleeve and the second annular electrical contact can be a split ring coaxially insertable within the sleeve to form an interference fit. The perforating system may further include an annular contact body threadingly attached to threads formed on an inner surface of the first perforating string member, threads on the end of the second perforating string member engageable with the threads on the first perforating string member, and a tiered contact body provided on the end of the second perforating string member, wherein the first annular electrical contact comprises a first ring on the annular contact body with a portion protruding from a surface of the body proximate the end, and wherein the second annular electrical contact comprises second ring on the tiered contact body with a portion protruding from a surface of the body proximate the end. The perforating system may optionally also have a plurality of first and second perforating string members, a control module associated with each first perforating string member and attached to each second signal member, and a signal circuit formed by the first and second members and the control module. In one example the control modules are arranged in parallel. The perforating system can alternatively further include a perforating gun, a connector sub connected to an end of the perforating gun, and a control module, wherein the first perforating string member comprises a control sub connected to an end of the connector sub opposite the perforating gun, the second perforating string member comprises a booster sub connected to the end of the control sub opposite the connector sub, wherein the perforating gun, connector sub, control sub, control module, and booster sub form a perforating string segment. In an embodiment, a series of

repeating perforating string segments makes up a perforating string. A first body may circumscribe the first annular electrical contact, having a bore through the body, and a detonator disposed in the bore. Also optionally included is a second body circumscribing the second annular electrical contact, and a booster charge disposed in the second body, so that initiating the detonator forms a initiates booster charge detonation.

Also disclosed herein is a method of perforating that includes providing first and second perforating string members, first and second annular contacts coaxially disposed respectively in the first and second perforating string members, first and second signal members respectively in communication with the first and second contacts, a detonation assembly in communication with the second signal member, and shaped charges detonatable in response to activation of the detonation assembly, orienting the first and second perforating string members so they are on about the same axis; and contacting the first and second annular contacts by connecting the first and second perforating string members and also providing communication between the first and second signal members via contact between the first and second annular contacts. Corresponding threads may further be provided on the first and second perforating string members wherein connecting the first and second string members includes engaging the corresponding threads and rotating one or both of the first and second string members. The first annular electrical contact may be a sleeve and the second annular electrical contact can be a split ring coaxially insertable within the sleeve to form an interference fit. Optionally, a perforating string segment can be provided that includes a connector sub connected on one end to an end of a perforating gun and on its other end to the first perforating string member and the second perforating string member connected to the end of the first perforating string member opposite the connector sub, wherein the first perforating string member comprises an aiming sub and the second perforating string member comprises a booster sub. In an examples, multiple perforating string segments can be provided to form a perforating string, the method further including deploying the perforating string in a wellbore, sending a detonation signal to the perforating string that initiates detonation of shaped charges in a particular perforating gun in the perforating string. A detonator associated with the shaped charges can be provided and a controller in communication with the detonator adapted to initiate the detonator when instructed by the detonation signal. The controller is configurable to respond to a coded signal.

The present disclosure also describes an example of a connector assembly for use in transferring signals between adjacent members of a perforating string. In an example, the assembly includes an electrically conductive annular sleeve coupled to a first member of the perforating string, an electrical signal member connected to the annular sleeve, a resilient ring connector coupled to a second member of the perforating string coaxially and disposed in an interference fit within the annular sleeve, and a wiring harness connected to the ring connector and in electrical communication with the electrical signal member via coupling between the annular sleeve and resilient ring. The connector assembly may also have a first body circumscribing the annular sleeve, a bore axially formed through the body, a centralizer circumscribing a portion of the body, a detonator and/or booster charge in the centralizer aligned with the bore, and a detonating cord operatively coupled with the detonator and/or booster charge. Optionally included is a second body having a portion circumscribed by the ring connector, a bore through the second body, a booster and/or detonator in the bore in the second body directed at the detonator and/or booster charge in the first body. The wiring harness can be in electrical communication with a conveyance system attached to an upper end of the perforating string and the electrical signal member is in electrical communication with a detonator and/or booster disposed in a third perforating string member.

BRIEF DESCRIPTION OF DRAWINGS

Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

FIG. **1** is partial cutaway side view of a prior art perforating system in a wellbore.

FIG. **2** illustrates a side sectional view of a prior art perforating gun.

FIG. **3** is a schematic of an example of a tool string connection.

FIG. **4**A depicts in a perspective view an example of male and female connectors.

FIG. **4**B provides a side sectional view of an example of the male and female connectors of FIG. **4**A.

FIG. **5** provides a side sectional view of the male and female connectors of FIGS. **4**A and **4**B in a portion of a gun string.

FIG. **5**A illustrates an enlarged view of a portion of FIG. **5**.

FIG. **6** provides an alternative example of a perforating string member connection.

FIG. **7** illustrates an example of a perforating string of the present disclosure in use.

While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system of the present disclosure may be in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be through and complete, and will fully convey its scope to those skilled in the art. Like numbers refer to like elements throughout.

It is to be further understood that the scope of the present disclosure is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation. Accordingly, the improvements herein described are therefore to be limited only by the scope of the appended claims.

A portion of a tool string **19** embodiment is schematically depicted in FIG. **3**, the tool string **19** portion includes string bodies **20**, **21** attached end to end. Tool string **19** embodiments include any string insertable within a wellbore, such as a drill string, perforating string, logging string, workover

strings, combinations thereof, and the like. Thus the string bodies **20**, **21** can be a perforating gun(s), a perforating gun connector(s), a drill string element(s), a string sub(s), a control module(s), as well as a member(s) in a logging and/or a workover string(s). Signal lines **22**, **23** are illustrated disposed respectively within the string bodies **20**, **21**. The signal lines **22**, **23** are in signal communication with one another via signal line connectors **24**, **25** provided on the line **22**, **23** ends. The signal lines **22**, **23** may be, wholly or partly, formed from any material or system for transmitting or conveying a signal. Signal embodiments include a message(s) (in digital or analog form having information), an electrical potential (that may or may not be time-varying either in presence or magnitude), an electromagnetic wave, that can be synchronous or asynchronous and may or may not have data embedded therein. Example electromagnetic waves include the full spectrum of light waves, radio waves, and microwaves. Example embodiments of signal lines **22**, **23** include electrically conductive material such as wires, strips, semiconductors, superconductive material, composites, and combinations thereof. Alternatively, signal lines **22**, **23** can be anything that transmits light waves, such as light pipes, optical fibers, reflective surfaces, and lenses. Yet further optionally, the signal lines **22**, **23** can be a series of transmitters for relaying signal(s) along the string **19** to and from the bodies making up the string **19**.

Example signal connectors **24**, **25** include electrically conducting members that register with one another and are brought into electrical contact/communication when the bodies **20**, **21** are attached. Optionally, the connectors **24**, **25** may be annular rings (not shown) that connect with attachment of the bodies **20**, **21**, fiber optic couplers, and/or receiver transmitters. Yet further optionally, the bodies **20**, **21** may include additional signal lines and connectors.

Further illustrated in the bodies **20**, **23** are detonation cords **26**, **27** through which a detonation wave may be transmitted. A first booster **28** is shown on the end of the detonation cord **26** adjacent the connection between the bodies **20**, **21**. In the embodiment of FIG. **3**, a detonation wave may travel on the end of the detonation cord **26**, opposite the detonator **28**. On reaching the first booster **28**, the detonation wave initiates the first booster **28** that in turn forms a ballistic detonation that transmits through the connection between the bodies **20**, **21**. A second booster **29** is shown on the end of the detonation cord **27** adjacent the connection between the bodies **20**, **21**. The second booster **29** is ignitable when exposed to the detonation transmitted from the first booster **28**; igniting the second booster **29** forms a detonation wave in the detonation cord **27** that travels along the cord **27** away from the second booster **29**. To ensure proper ballistic transfer between the bodies **20**, **21** the first booster **28** and second booster **29** are placed in alignment. In one example, the first booster **28** and second booster **29** are coaxially disposed within their respective bodies **20**, **21**. Thus in one example of use the tool string **19** of FIG. **3** includes a connection enabling a ballistic transfer and a signal transfer. The first and second boosters **28**, **29** may be substantially the same. Alternatively, the first booster **28** may include a transfer charge, so that detonation transfer can occur when the connection between the bodies **20**, **21** includes a bulkhead or is otherwise sealed.

FIGS. **4**A and **4**B provide an alternate embodiment of a connector enabling signal and ballistics communication between adjacent tool string members. The connectors of these figures can be used in a perforating system between adjacent string bodies. The connectors may be referred to as male and female connectors that are on separate string bodies and when the bodies are attached the connectors become coupled. An example of male and female connectors **30**, **50** are illustrated in a side perspective view in FIG. **4**A. The male connector **30** includes an annular cylindrical body **32** having an end circumscribed by an annular contact ring **34**. A bore **40** extends axially through the body **32**. Longitudinally formed along the body **32** on its outer surface is a channel **33** with a wiring harness **36** therein.

The female connector **50** of FIG. **4**A includes an annular outer body **52** open on one side with a rear wall **57** on the other having a bore **58** therethrough. Coaxial within the body **52** is a circular contact sleeve **56** having a rearward lateral side abutting the rear wall **57**. A rearward extension **53** is shown depending from the rear wall **57** away from the body **52**. A tab connector **54** is partially housed within the rearward extension, a portion of which projects from the back of the rearward extension **53**.

A side partial sectional view of the male and female connectors **30**, **50** is provided in FIG. **4**B. The wiring harness **36**, as shown in FIG. **4**B, has an end in electrical communication with the annular contact ring **34** and an electrical connector **38** attached its free end. Shown on the rearward portion of the connector **30** is an annular skirt **39** having an optional groove **41** formed on its inner surface and slots **42** formed longitudinal thereon. As illustrated in FIG. **4**B, the wiring harness **36** attaches to an inner ring **35** coaxial between the contact ring **34** and body **32**. The contact ring **34** and inner ring **35** may each or individually be, electrically conductive, resilient, and may include a split section (not shown). The split section allow the rings **34**, **35** to be radially compressed and being formed from a resilient material, the rings **34**, **35** will exert a force radially outward when compressed. A detonator **44** is shown co-axially inserted within the bore **40** in the embodiment of the male connector **30** of FIG. **4**B. Transfer charge wires **46** connect to an end of the detonator **44**. As will be described in more detail below, providing an electrical current through the charge wires **46** can initiate the detonator **44** to produce an explosive charge for detonating shape charges.

Shown in the sectional view of FIG. **4**B, the tab connector **54** connects on an inward side with the contact sleeve **56**. An electrical signal member **55** is shown attached to one of the tab connectors **54**, as will be described in more detail below, the signal member **55** can be used for transmitting/receiving a signal to/from another portion within a perforating string. A booster charge **60** is positioned with a free end aligned with the bore **58** and its opposite end having a crimped connector **62**. The booster charge **60** as shown is not connected, but illustrated in a position approximately to its assembled location.

FIGS. **5** and **5**A depict an example of a perforating system **70** having the male and female connectors **30**, **50** for transferring signals between adjacent perforating string members. For the purposes of discussion herein, signals includes data signals, electrical signals, and signals in the form of detonation waves. In the embodiment of FIGS. **5** and **5**A, the male and female connectors **30**, **50** are shown disposed within a booster sub **72**, which is an annular member shown having a box connection configured to receive an end portion from an arming sub **76**. A pin type connection on the booster sub **72** opposite side is inserted within the box type connection of a perforating gun **74**.

As shown, the end of the male connection **30** having the annular contact ring **34** is inserted within the female connector **50** open end. This contacts the annular contact ring **34** on its outer surface to the contact sleeve **56** inner surface. As noted above, the optional split section in the rings **34**, **35** allows them to be radially compressed when inserted within the contact sleeve **56**. Due to the resilient material used in

forming the rings **34**, **35**; when they are radially compressed by a force, up to their yield point, potential energy is stored in the rings **34**, **35** forcing them outward into their pre-compressed state. Thus by dimensioning the rings **34**, **35** and sleeve **56** so that the rings **34**, **35** are radially compressed when inserted into the sleeve **56**; stored stress in the rings **34**, **35** forces them radially outward into sustained contact with sleeve **56**. Electrical communication between the male and female connectors **30**, **50** is initiated and maintained by the springlike interference fit between the rings **34**, **35** and sleeve **56**. The male connector **30** is supported within the booster sub **72** by a control sub sleeve **77**. The skirt **39** portion of the connector **30** snaps over the sleeve **77** end. The groove **41** on the skirt **39** inner surface fits over a lip circumscribing the sleeve **77** end, the slots **43** expand to allow the skirt **39** to slide over the sleeve **77** end and the groove **41** to engage the lip.

Illustrated in schematic form in FIG. **5** is a control module **84** and a detonator electrical supply **86**; both housed within the arming sub **76**. In an example of use, the detonator electrical supply **86** selectively provides electrical current to the connected transfer charge wires **46** sufficient to activate the detonator **44**. The control module **84** is operatively coupled to the detonator electrical supply **86** and regulates electrical current from the electrical supply **86**. The control module **84** can include a printed logic circuit board with instructions stored in media thereon or hardwired within a circuit on the board. The detonator electrical supply **86** can have electrical energy stored therein, and thus can include a battery, a capacitor, or the like. Optionally, the detonator electrical supply **86** can include an electrical generator. The detonator electrical supply **86** may be separate or integral with the control module **84**.

The step of regulating electrical current from the electrical supply **86** can include controlling when electrical current flows from the electrical supply **86**, for how long the current flows, and how much current flows. The arming sub **76** has a pin type to box type connection to a connector sub **71** which is attached on its upper end and a pin to box type connection to the lower end of a perforating gun **74**. Signal member **55** depending from an upper tab connector extends through the perforating gun **74**, through a bore **85** axially formed through the connector sub **71** and terminates into connection at the control module **84**. A bypass line **37** connects on one end to the signal member **55** and on the other to an electrical connector **38** of a wiring harness **36**. Provided with each repeating section of the perforating system **70** are a signal member **55**, bypass line **37**, connector **38**, wiring harness **36**, rings **34**, **36**, sleeve **56**, and tab connector **54** that form a circuit placing each control module **84** in parallel on the circuit.

Further depicted in FIGS. **5** and **5**A is a detonating cord **63** shown attached within the crimped connector **62** on the booster charge **60**. A centralizer **73** shown in the booster sub **72** has an annular receptacle **81** in which the rearward extension **53** of the female fitting **50** is inserted. The centralizer **73** supports and aligns the female connector **50** within the booster sub **72** for coupling to the male connector **30** when connecting the arming and booster subs **76**, **72**. Also in the receptacle **81** is the connection between the electrical signal member **55** and tab connector **54**. The centralizer **73** also includes an axial bore **83** in which the booster charge **60** and crimped connector **62** are inserted. Placing the booster charge in the bore **83** aligns it with the detonator **44**.

Alternative connectors between a perforating gun **74**A and connector sub **71**A are depicted in a side partial sectional view in FIG. **6**. A gun box opening **87** in the perforating gun **74**A is threaded on its inner surface in which a connector assembly **88** is threadingly connected. The connector assembly **88** includes an annular ring like contact body **90** threaded on its outer circumference for attachment to the threads on the perforating gun **74**A. An annular contact **91** is included with the contact body **90** disposed coaxial with the perforating gun **74**A and having at least a portion projecting upward from the contact body **90** towards the gun box opening **87**. A tube base **93** is shown secured in the gun body **74**A abutting a side of the contact body **90** opposite the annular contact **91**.

A wiring harness **36**A connects to the annular contact **90**. Threads on the connector sub **70**A define a connector sub pin end **89**, where the threads are configured to attach to the threads in the perforating gun box opening **87**. A contact assembly **94** is provided in the terminal end of the connector sub pin end **89** that includes a contact body **96**. The contact body **96** is a cylindrically tiered member coaxially mounted at the sub **71**A end. The contact body **96** shown includes two tiers, with the larger tier at the sub **71**A end surface and facing the gun box opening **87**. An annular ring contact **95** is mounted on the upper/outer surface of the larger tier and configured to substantially match the contour of the annular ring **91**. A bore **64** is shown formed coaxial within the connector sub **71**A that extends into the contact body **96**. A booster charge **60** and associated detonating cord **63** are provided in the bore **64**. A signal member **97** connects on one end to the annular ring **95** and extends into the connector sub **71**A through the bore **64**. Rotating one or both the connector sub **71**A and perforating gun **74**A while engaging their respective threads couples these members and also connects the assemblies **88**, **94** thereby making up signal communication between the connector sub **71**A and perforating gun **74**A.

In FIG. **7**, an example of use of the perforating system **70** described herein is schematically depicted in a side partial sectional view. A perforating system **70** in accordance with the present disclosure is deployed within a wellbore **1**A for perforating into a formation **2**A adjacent the wellbore **1**A. A connected wireline **69** suspends the perforating system **70** in the wellbore **1**A from a pulley system **3**A. The wireline **69** upper end is shown terminating in a truck **7**A on the surface **9**A, from which the wireline **69** can be spooled. The truck **7**A can include hardware and software for controlling and communicating with the system **70**. Tubing, slickline, or other conveyance means can be used in place of a wireline. Alternatively a surface module at the surface **9**A or remote from the wellbore **1**A can be used for control and/or communication with the system **70** instead of the truck **7**A.

The perforating system **70** of FIG. **7** includes a repeating string of perforating guns $\mathbf{74}_{1\text{-}n}$, each perforating gun $\mathbf{74}_{1\text{-}n}$ having a booster sub $\mathbf{72}_{1\text{-}n}$ attached on its upper end, and each booster sub $\mathbf{72}_{1\text{-}n}$ with an arming sub $\mathbf{76}_{1\text{-}n}$, wherein the arming sub $\mathbf{76}_{1\text{-}n}$ may be attached to an adjacent perforating gun $\mathbf{74}_{1\text{-}n}$ via a connector sub $\mathbf{71}_{1\text{-}n}$. As noted above, one or more particular perforating guns $\mathbf{74}_{1\text{-}n}$ within the perforating string **70** may be selectively activated by detonating shaped charges **80** in the particular gun $\mathbf{74}_{1\text{-}n}$. In the example shown, shaped charges **80** in the lower most perforating gun **74***n* have been detonated to produce perforations **10**A in the formation **2**A. The shaped charges **80** may include high explosive and a liner **98**, so that igniting the high explosive creates jets **12**A shown projecting radially outward from detonating shaped charges **80** that form the perforations **10**A. After detonation, the system **70** can be relocated within the wellbore **1**A and one or more particular undetonated perforating guns $\mathbf{74}_{1\text{-}n}$ within the string then detonated. Alternatively, subsequent detonations can take place without readjusting the gun string in the wellbore **1**A.

Each control module $\mathbf{84}_{1\text{-}n}$ can be configured to respond based on a particular signal or signals, wherein module $\mathbf{84}_{1\text{-}n}$

response includes controlling the detonator electrical supply 86_{1-n}. Electrical signals from the surface can be transmitted downhole via wireline **69** and transferred to the signal member **82** extending within the perforating string. The signal may be data encoded or may be a sequence of signals. The control modules **84** can be configured to register each signal sent down the wireline, but only act on signals that include a particular code. Optionally, the modules **84** can be configured to register only signals having a particular code. Full instructions for each control module **84** can be in the signals sent downhole or the control modules **84** can be equipped with one or more sets of instructions that are carried out depending on the signal content received. As shown in FIGS. **5** and **5**A, the signal circuit places each control module **84** in parallel, thus each control module **84** in the string can receive a signal sent via the signal member **82**. An optional signal circuit configuration places each control module **84** in series.

Based upon the particular signal in the signal circuit, the control module **84** can then activate the detonator electrical supply **86** so that electrical current is delivered to the detonator **44**. However, if the signal received by the particular control module **84** is meant to detonate shaped charges **80** within a perforating gun **74** not associated with the control module **84**; as described above, the control module **84** will not act until the appropriate signal is received. In situations when shaped charges **80** of other perforating guns **74** are to be activated, the signal can still pass to the wiring harness **36** via its associated connector **38** either within the control module **84** or through direct connection with the signal member **82**. The signal within wiring harness **36** is conducted to the inner ring **35** and annular contact ring **34**, transferred to the contact sleeve **56** in the female connector **50** and sent further down the string via electrical signal member **55**. Accordingly, one of the advantages of the device described herein is the capability of providing connectivity, both electrical and detonation, between adjacent members within a perforating string **70**.

The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. The signal members described herein can include anything through which a signal can travel. Examples include metallic elements, such as wires and/or strips, optical fibers, semiconductors, composites, combinations thereof, and the like. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.

What is claimed is:

1. A tool string for use downhole comprising:

a first body having a first signal line in signal communication with a wireline;

a second body attached to the first body having a second signal line;

a signal line connection assembly coupled between the first and second bodies and that comprises a female connector with an annular contact sleeve, and a male connector that selectively inserts into the female connector, the male connector having an annular contact ring that circumscribes a first booster charge and that is coaxially disposed within the contact sleeve when the male connector inserts into the female connector and is in signal communication with the female connector, so that when the first and second bodies are attached the first and second signal lines are in signal communication through the signal line connection assembly; and

a ballistics transfer assembly that comprises the first booster charge and that is coupled on the respective ends of the first and second bodies, so that when a detonation wave in the first body reaches the ballistics transfer assembly to form a ballistic detonation that transmits to the second body and initiates a detonation signal in the second body.

2. The tool string of claim **1**, further comprising a first detonating cord in the first body coupled to an end of the first booster charge and a second detonating cord in the second body coupled to the end of the ballistics transfer assembly opposite the first detonating cord.

3. The tool string of claim **2**, wherein the ballistics assembly further comprises a second, booster charge attached on an end of the second detonating cord, the first booster charge directed to the second booster charge.

4. The tool string of claim **1**, wherein the first and second bodies are selected from a list consisting of a perforating gun(s), a perforating gun connector(s), a string sub(s), a control module(s), a drill string element(s), a logging string element(s), a workover string element(s), and combinations thereof.

5. The tool string of claim **1**, wherein the first and second signal lines and the signal connection assembly are selected from the list consisting of electrically conducting elements, optical members, electromagnetic wave transfer elements, and combinations thereof.

6. A perforating system comprising:

a first perforating string member comprising:

a first annular contact comprising a first contact body that is threadingly attached to threads formed on an inner surface of the first perforating string member, and a first ring on the first contact body having a portion protruding from a surface of the first contact body;

a first signal member in communication with the first annular contact and in signal communication with a wireline;

an end having a first connection fitting;

a second perforating string member comprising:

a second annular contact comprising a tiered second contact body on an end of the second perforating string member proximate the first perforating string member, and a second ring on the second contact body that has a portion protruding from a surface of the second contact body;

a second signal member in communication with the second annular contact; and an end having a second connection fitting selectively in a configuration attached with the end having a first connection fitting, so that when the end having a second connection fitting is attached to the end having the first connection fitting, the first and second annular contacts are contacting and the first and second signal members are in signal communication;

detonating cord disposed in the first and second perforating string members; and threads on the end of the second perforating string member engageable with the threads on the first perforating string member, so that when the first and second perforating string members are engaged, the first ring contacts the second ring.

7. The perforating system of claim **6**, wherein the perforating string members are selected from the list consisting of a perforating gun, a connecting sub, a booster sub, and a control sub.

8. The perforating system of claim 6, wherein the first and second annular contacts are coaxially arranged.

9. The perforating system of claim 6, wherein the first annular contact comprises a sleeve and the second annular contact comprises a split ring coaxially insertable within the sleeve to form an interference fit.

10. The perforating system of claim 6, further comprising a plurality of first and second perforating string members, a control module associated with each first perforating string member and attached to each second signal member, and a signal circuit formed by the first and second members and the control module, wherein the control modules are arranged in parallel.

11. The perforating system of claim 6, further comprising a perforating gun, a connector sub connected to an end of the perforating gun, and a control module, wherein the first perforating string member comprises a control sub connected to an end of the connector sub opposite the perforating gun, the second perforating string member comprises a booster sub connected to the end of the control sub opposite the connector sub, wherein the perforating gun, connector sub, control sub, control module, and booster sub form a perforating string segment.

12. The perforating system of claim 11, wherein the perforating system comprises a series of repeating perforating string segments.

13. The perforating system of claim 11, further comprising a second body circumscribing the second annular contact, and a booster charge disposed in the second body, so that initiating a detonator in the first perforating string member initiates booster charge detonation.

14. The perforating system of claim 6, further comprising a first body circumscribed by the first annular contact, a bore through the body, and a detonator disposed in the bore.

15. A method of perforating comprising:

providing first and second perforating string members each having a detonation cord, annular ring and sleeve contacts coaxially disposed respectively in the first and second perforating string members, a first signal member in communication with the ring contact and in signal communication with a wireline, a second signal member in communication with the sleeve contact, a detonation assembly in communication with the second signal member, a portion of the detonation assembly circumscribed by the ring contact, and shaped charges detonatable in response to activation of the detonation assembly;

orienting the first and second perforating string members so they are on about the same axis; and

urging the first and second perforating string members in an axial direction and into connection, which also contacts together the strategically located ring and sleeve contacts into an interference fit to provide communication between the first and second signal members via contact between the ring and sleeve contacts.

16. The method of claim 15, wherein corresponding threads are further provided on the first and second perforating string members and wherein connecting the first and second string members includes engaging the corresponding threads and rotating one or both of the first and second string members.

17. The method of claim 15, wherein the ring contact comprises a split ring coaxially insertable within the sleeve to form an interference fit.

18. The method of claim 15, further comprising:

providing a perforating string segment that comprises a connector sub connected on one end to an end of a perforating gun and on its other end to the first perforating string member and the second perforating string member connected to the end of the first perforating string member opposite the connector sub, wherein the first perforating string member comprises an arming sub and the second perforating string member comprises a booster sub.

19. The method of claim 18, further comprising providing multiple perforating string segments to form a perforating string, deploying the perforating string in a wellbore, sending a detonation signal to the perforating string that initiates detonation of shaped charges in a particular perforating gun in the perforating string.

20. The method of claim 19, further comprising providing a detonator associated with the shaped charges and a controller in communication with the detonator adapted to initiate the detonator when instructed by the detonation signal.

21. The method of claim 20, further comprising configuring the controller to respond to a coded signal.

22. A connector assembly for use in transferring signals between adjacent members of a perforating string, the connector assembly comprising:

an electrically conductive annular sleeve coupled to a first member of the perforating string;

an electrical signal member connected to the annular sleeve;

a resilient ring connector coupled to a second member of the perforating string coaxially disposed in an interference fit with the annular sleeve and in electrical contact;

a wiring harness connected to the ring connector and in electrical communication with the electrical signal member via coupling between the annular sleeve and resilient ring;

a first body circumscribing the annular sleeve, a bore axially formed through the body;

a centralizer circumscribing a portion of the body; and

a booster charge in the centralizer aligned with the bore, and a detonating cord operatively coupled with the booster charge.

23. The connector assembly of claim 22, further comprising a second body having a portion circumscribed by the ring connector, a bore through the second body, a detonator in the bore in the second body directed at the booster charge.

24. The connector assembly of claim 22, wherein the wiring harness is in electrical communication with a conveyance system attached to an upper end of the perforating string and the electrical signal member is in electrical communication with a detonator disposed in a third perforating string member.

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